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A MODEL TO PREDICT SHOPPER REACTION
TO COMMISSARY STOCKOUTS

THESIS

Jose L. Torres, Jr., Captain, USAF

AFIT/GLM/LSC/90S-59

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AFIT/GLM/LSG/90S-59

A MODEL TO PREDICT SHOPPER REACTION

TO COMMISSARY STOCKOUTS

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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Captain, USAF

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Preface

In performing this research and writing this thesis, I have received a great deal of help from many people. I would like to thank the management of the Wright-Patterson AFB Commissary for providing background information. I am also indebted to my advisor, Lieutenant Colonel Larry Emmelhainz. Without Lt Col Emmelhainz's guidance, patience, and encouragement, this thesis would never have been possible. I would also like to acknowledge the assistance I received from Professor Daniel E. Reynolds.

Finally, I would like to thank my wife, Angelina, for the support and understanding she provided throughout this process.

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Abstract

The purpose of this research was to determine whether existing information about out-of-stock behavior could be used to develop a model of the out-of-stock behavior of commissary patrons. The Wright-Patterson Air Force Base Commissary was losing sales because of stockouts. While more inventory was a logical solution, inventory carrying costs and space limitations restricted the amount of inventory that can be carried.

This study developed and analyzed product specific and general out-of stock models which were developed using the SAS discriminant analysis procedure. It was determined that demographics and shopper characteristics provided the best predictors of the decision to substitute and the brand, size, and variety of the substitute product. Although none of the general out-of-stock models were determined to be useful (a correct rate greater than 80 percent), three product specific models were determined to be useful. Furthermore, the demographic variables were determined to be much more functional than the purchase situation and shopper characteristic variables. Finally, since the size models generally produced results which were far from desired, this

research suggests there is no structured method of predicting size given the three variable types.

A MODEL TO PREDICT SHOPPER REACTION

TO COMMISSARY STOCKOUTS

I. Introduction

Background

The mission of the Wright-Patterson AFB Commissary includes the operation of a resale store that provides service and facilities for the sale of Department of Defense (DOD) authorized merchandise at the lowest price to authorized patrons (military retirees, active duty members and their dependents). The commissary (resale store) is operated much like a civilian supermarket with three basic departments - grocery, produce, and meat. When available, delicatessens and bakeries are operated by contracted vendors (AFCOMSP 40-1, 1989:4).

DOD operates military commissaries for three broad reasons: (1) as an economic benefit to military people; (2) as the sole source of United States food and household goods overseas; and (3) to give military members and their families an important sense of "belonging" (AFCOMSP 40-1, 1989:3). Commissaries provide economic relief in the form of nonpay compensation to military people and their families

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by selling merchandise at cost plus a 5 percent surcharge. This surcharge covers operating expenses required by law including utilities, construction, supplies, equipment, and maintenance of equipment. Additionally, by satisfying the important need of members and their families to belonging to a caring organization, commissaries partially offset the rigors and family separations that are a part of military life (AFCOMSP 40-1, 1989:3).

The WPAFB Commissary is given much guidance from Headquarters Air Force Commissary Service (HQ AFCOMS). HQ AFCOMS provides a master store layout that determines the amount of linear shelf space allowed for each commodity group. Additionally, HQ AFCOMS provides a master product list of the authorized merchandise which includes approximately 14,300 items. Some items must be carried by the commissary; however, local management is given the discretion to carry or not to carry those items which are not mandatory (Johnson Interview, 1989).

The WPAFB Commissary has average monthly sales of $4.2 million, but it varies 12 percent to 15 percent. These sales are generated by the more than 12,000 individual products carried by the commissary. Of these, 55 percent to 65 percent are stocked in the 25,000 sq. ft. warehouse. The remaining items are restocked through local grocery

distributors on a daily or frequent delivery basis (Johnson Interview, 1989).

Customer service goals of the WPAFB Commissary include providing a complete range of commodity groups, offering a choice f brands and sizes for each product type in a commodity group, and providing a 99 percent in-stock rate for all products carried. In order to support this high rate of customer service and monitor the stock levels, the commissary installed the Automated Commissary Operation System (ACOS) in 1987. ACOS is supported by the NCR 9150 and 9300 computers. The NCR 9150 is the scanning system used at the check-out counters. It reads the Universal Product Code (UPC) of each item and queries the database stored in the NCR 9300 for the item's name and price. ACOS stores the number of times it is queried for a specific item, thus providing a record of unit sales. These records are used to produce monthly sales reports. The ACOS database stored on the NCR 9300 consists of store inventory, vendor data, charge sale accounts, and the general ledger. Through the interface with hand-held computers, the database can be updated with actual product inventories. A laser wand attached to the hand-held computer reads the UPC on the shelves. Once the UPC is read, the employee takes inventory and keys it into the computer. When finished, the employee electronically transfers the inventories into the NCR 9300

(AFCOMSP 40-1:9-10 and Johnson Interview, 1989).

This system was designed to maintain a perpetual inventory for each site; compute suggested orders based on sales, inventory, and due-ins; provide an inquiry capability to eliminate large printed reports; automate charge sales; provide an interface with hand-held computers used for inventory, receiving and price audits; electronically interface with other agencies such as accounting and finance; and provide an automated scanning price update direct from the regions to each store (AFCOMSP 40-1, 1989:9).

General Issue

Although the commissary has spent much time, effort, and money to obtain accurate inventories, there is evidence which suggests the customer service goal of providing a 99 percent in-stock rate for all products is not being met. Research conducted at the WPAFB Commissary found that 1,182 (42%) of the 2,810 customers that were surveyed had encountered an actual stockout (Emmelhainz and others, 1989:5).

As with all retailers, the Wright-Patterson AFB Commissary must choose among different levels of customer service. Customer service, as considered in this thesis, is the amount of product inventory and selection (variety)

stocked by the commissary. By definition, there are two dimensions in which customer service can generally be improved through increased inventory. Either the inventory of a single product or the inventory of the overall selection can be increased to improve customer service. However, these increases in inventory can result in expensive inventory carrying costs. The challenge is to determine the most appropriate customer service and inventory level.

In 1988 at the WPAFB Commissary, Emmelhainz and others created stockout conditions for five grocery products - orange juice, toothpaste, peanut butter, coffee, and tomato sauce (Emmelhainz and others, 1989:4). Randomly selected customers at the check-out lane were then questioned by the researchers. The researchers asked shoppers if they were looking for any of the five out-of-stock products, and if so, had they been able to find the exact item with respect to size, brand, and variety. If the item the customer wanted was not available, the researchers further questioned the shopper to determine what specific actions were taken instead (Emmelhainz and others, not dated:1).

Of the 2,810 customers surveyed, 375 (13.3%) did not find the specific item they wanted. Of those 375 customers, 49 (13.1%) stated they would go to another store to purchase the item (Emmelhainz and others, 1989:7).

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Specific Problem

The Wright-Patterson AFB Commissary is losing sales because of stockouts. While more inventory is a logical solution, inventory carrying costs and space limitations restrict the amount of inventory that can be carried. While the general reactions to out-of-stock behavior have been identified from the Emmelhainz and others research, it is not known whether individual demographic, product, and purchase situation characteristics can be used to model stockout behavior and to manage commissary inventory within existing constraints.

The overall objective of this research is to determine whether existing information about out-of-stock behavior can be used to develop a model of the out-of-stock behavior of commissary patrons.

Investigative Questions

1. To what extent can demographic characteristics be used to predict out-of-stock behavior?

2. To what extent can purchase situations be used to predict out-of-stock behavior?

3. To what extent can shopper characteristics be used to predict out-of-stock behavior?

4. To what extent can demographic data reflecting the commissary market area be used to predict the out-of-stock behavior of commissary patrons?

5. To what extent can a model be developed for a specific product?

6. To what extent can a general out-of-stock model be developed from multiple products?

7. To what extent can a model developed from half of the data predict the reported behavior of the other half of the patrons?

8. To what extent does a model based upon all of the data outperform data based upon half of the data?

Justification

In these days of shrinking budgets, new methods must be conceived to make better use of the financial resources currently available. Efforts should be directed at helping the WPAFB Commissary better meet consumer demand without increasing its inventory carrying costs. By being able to predict consumer reaction to stockouts, the commissary will have the information necessary to better position its inventories. It is hoped that strategic placement of inventory will result in a decrease in lost sales due to stockouts and a reduction of total inventory.

Scope and Limitations of the Study

This research is limited to the survey data c llected by Emmelhainz and others in their 1988 research at the WPAFB Commissary. The customers' responses to the survey

questions form the database of this study. More specifically, this research will use consumer responses to out-of-stock situations, consumer demographics, product information, and purchase situations in order to answer the research questions.

The research questions will be answered in the four remaining chapters. Chapter II, Literature Review, consists of research conducted on inventory costs, brand switching, and previous stockout models. Chapter III, Methodology, will provide the approach used to answer the research questions. The results of the statistical models will be presented in Chapter IV, Analysis. Finally, Chapter V, Conclusion, will consist of conclusions derived throughout this effort as well any recommendations offered in managing stockout costs.

II. Literature Review

Introduction

To provide background on customer service and stockout costs, four subject areas will be reviewed. The first subject area will provide a brief background on inventory costs, the trend to maintain smaller inventories, and methods of reducing inventory without reducing customer service.

The second section discusses current customer service practices of some of major firms and the results of those practices. In the third section, the stockout decision tree is examined. Finally, the fourth subject area reviews the results of some brand switching studies.

Inventory Costs

The trend to closely monitor inventory carrying costs appears to have begun in the 1980s. Until then, management was not overly concerned with those costs. As stated by Beman, "In the 1970s, inventory profits from inflation tended to offset financing charges. Because interest rates now exceed inflation, inventories have become the most volatile element of the cost of production - and a major threat to profits" (Beman, 1981:76). In 1974, U.S. nonfarm business carried a stockpile that averaged $332 billion (Beman, 1981:77). The inventory carrying costs for that

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year were less than $10 billion (Beman, 1981:77). In the
first quarter of 1981, inventories were at $710 billion but
inventory carrying costs were more than $110 billion at an
annual rate (Beman, 1981:77). As may be seen, while 1981
inventories were a little more than twice as large as
inventories in 1974, the 1981 inventory carrying costs were
more than ten times those of 1974. Although Beman's article
illustrates how carrying costs have increased so
dramatically, there were executives in 1983 who still
preferred to "operate on the heavy side as far as stock goes
... to avoid being caught short" (May and others, 1983:42).

By 1984, concern over inventory carrying costs
intensified. Brownstein reports that in the late 1970s
inflation "sapped any urgency" companies might have had in
controlling inventory (Brownstein, 1984:20). Businesses
were more concerned with stocking up before prices rose.
Brownstein states that in 1984 because price increases were
slower, interest rates were still high, and computer
technology was becoming affordable, businesses were
beginning to invest in major improvements in managing
inventory (Brownstein, 1984:20). The changing focus was
captured by a 1986 Fortune survey. Nearly two-thirds of the
executives surveyed stated they would rather have too little
inventory than too much (May and others, 1986:31). This

survey demonstrates the drastic changes in management philosophy since the 1970s.

After management realized how expensive inventory carrying costs were, they were looking for techniques to decrease inventory. One method which Finkin reported is to eliminate obsolete inventory (Finkin, 1989:50). Finkin stated that products or raw materials in storage, unlike wine, do not improve with age (Finkin, 1989:50). Firms hesitate to dispose of obsolete items because management does not want to show the resulting loss on the financial statements. However, it is better to show the loss and recover some cash than to continue to incur the costs of maintaining the inventory (Finkin, 1989:50). By eliminating the unproductive material, capital can be recovered and freed for more productive use (Finkin, 1989:50). One method of disposing obsolete material is to sell it to a "rebuy" warehousing company (Finkin, 1989:50).

Another method of reducing inventory, while simultaneously increasing customer service, is to reduce the amount of "sludge" inventory. White defined sludge as slow-moving, inactive inventory (White, 1989:43). Because most inventory managers concentrate on the total dollar amount of inventory, sludge slowly increases and customer service declines (White, 1989:43). As sludge slowly increases, it squeezes out the faster-moving inventory, which support

almost all of the sales (White, 1989:43). This results in the faster moving items being stocked out more frequently (White, 1989:43). Therefore, when customers ask for one of the faster moving items, they are unavailable, and the frustrated customers decide to call on competitors (White, 1989:43). This method is similar to ABC analysis which Armstrong reports in his article. The concept behind ABC analysis is Pareto's Law, the 80-20 rule (Armstrong, 1985:48). Because this law is applicable to business, management can estimate that 20 percent of the company's products account for 80 percent of the sales and 20 percent of the company's customers account for 80 percent of the sales (Armstrong, 1985:48). By identifying the more profitable customer-product combinations, management can increase the inventory of these fast moving products to ensure they are adequately stocked to meet the demand from more profitable customers (Stock and Lambert, 1987:130). Meanwhile, the customer service level of the "not-as-profitable" customer-product combinations are reduced. Since the product inventories of this combination represent approximately 80 percent of the total inventory, their inventory reduction can effectively reduce the total inventory and hence, reduce inventory carrying costs.

Customer Service

Although the previous section discussed methods of maintaining customer service levels while decreasing inventory, this section will discuss other aspects of customer service. Customer service is receiving increasing attention because many firms have found that it is more profitable to listen to and attempt to alleviate customer complaints than it is to ignore them. Studies have shown that customers tell twice as many people about bad experiences than they tell about good experiences (Sellers, 1988:88). These "horror" stories can destroy a company's image. Other studies have shown that "keeping a customer typically costs one-fifth as much as acquiring a new one" (Sellers, 1989:38). For these reasons, many firms such as British Airways, Coca-Cola, Domino's Pizza, Four Seasons Hotels, General Electric (GE), and General Motors (GM) have invested and continue to invest millions of dollars to improve complaint handling capabilities through the installation of toll-free 800-number telephone systems, intensive staff training, and liberal refund policies (Sellers, 1988:89 and Sellers, 1989:39).

In 1987, Continental, Eastern, and Pan American airlines which often rank near the top of the Department of Transportation's monthly tallies of airlines that attract the most consumer complaints lost a combined total of $714.4

million (Sellers, 1988:89). During the fiscal year that ended March 31, 1988, British Airways posted a net income of $189 million (Sellers, 1988:92). Unlike some of the other airlines, British Airways has a tendency to give full refunds, write letters of apologies, and charter planes to fly passengers to their destinations when technical problems result in customers being grounded somewhere other than their destinations (Sellers, 1988:92).

GM has also found that it is profitable to listen to the consumer. In 1984, GM shrank the Cadillac two feet which caused sales to stall. Over a three year period, GM planners met with 2,500 owners of Cadillacs and other models to discuss design ideas. These idea exchanges resulted in GM adding nine inches, subtle tail fins, and fender skirts to the 1989 De Ville and Fleetwood (Sellers, 1989:38). As a consequence, fourth quarter 1988 sales of Cadillac Fleetwoods and De Villes were 36 percent more than the year before (Sellers, 1989:38).

Another example of a desire to increase customer service may be found at Domino's Pizza. Each year, Domino's pays ten thousand "mystery customers" sixty dollars each to buy twelve pizzas throughout the year (Sellers, 1989:40). In return, these customers, which are spread across Domino's five thousand units, are asked to evaluate the quality and service of the local unit. These evaluations, in part,

determine the unit manager's compensation (Sellers, 1989:40).

Other studies on customer service have found that many factors influence the consumer's choice of retailers. In his research at Navy Commissaries, Morey found that factors such as nearness to customer, store image, accessibility of site, acceptability of credit cards, store name, the time waiting in line, and the ability to keep the shelves stocked affect the level of sales (Morey, 1975:90). He concluded that a one percent increase in customer service results in a 2.9 percent increase in sales (Morey, 1975:90).

As the number of families with both spouses employed increases, Umesh and others stated time sensitivity is becoming a critical factor in a customer's choice of retail stores (Umesh and others, 1989:715). Because highly time-sensitive consumers place such a high value on time, they are often willing to trade other resources to save time (Umesh and others, 1989:715). The researchers found that at the .05 level, only two demographic variables - employment level and level of education - were significant in distinguishing low time-sensitive consumers from highly time-sensitive consumers (Umesh and others, 1989:725).

Stockout Decision Tree

As may be seen from the inventory cost section, strategic planning of inventories is of the utmost importance to ensure tolerable inventory carrying costs and adequate customer service. However, because management cannot perfectly forecast demand, a reduction in inventory may result in "being caught short." What is the price of "being caught short?" In other words, what is the price of a stockout?"

Walter and Grabner's article states that most inventory optimization models acknowledge stockout costs as a significant variable, however, the model builders avoid having to measure these costs by assuming a desired level of service or by substituting a simplified penalty function for stockouts (Walter and Grabner, 1975:56). The rationale for the lack of models dealing with stockouts is that the costs are "indeterminate" because of the uncertainty as to what the consumer reaction to the stockout will be (Walter and Grabner, 1975:56).

When a customer arrives at a retail store with a specific item in mind (specific product, brand, and size) and discovers the store is out-of-stock, the customer is faced with a myriad of decisions to make. These decisions may be traced in Appendix B. The consumer must first decide whether to substitute for another size or brand, search for

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the same product at a different store, or make a return trip.

If, from the onset, the consumer decides to look for the product at a different retail store, then the initial retailer experiences a lost sale, and maybe even a lost customer if the consumer perceives an increase in customer service at the ensuing store.

By deciding to remain within the initial store, the customer must decide to return at a later date or accept a substitute. When the decision is to return, the initial retailer and manufacturer retain the sale. When the substitute path is chosen, the consumer must decide to purchase a different size of the original brand or a brand whose price is higher than, lower than, or equal to the price of the original brand. By remaining with the original brand, the manufacturer retains the sale. If the consumer switches brands, the manufacturer loses a sale, and maybe a customer if the consumer perceives the substitute is a better product. As may be seen stockouts create the opportunity for the consumer to sample other retailers and manufacturers' products.

By delivering 14,820 questionnaires to ten Ohio liquor stores and by having the cashiers include the questionnaires in the sack of each purchase, Walter and Grabner were able to gather information on typical consumer responses to

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liquor stockouts. Of the 1,433 respondents, 59.1 percent stated that if the desired product was out-of-stock, they would switch brands but remain in the same price range (Walter and Grabner, 1975:59). 19.1 percent of the respondents stated they would purchase the same brand but a different size while 14.1 percent stated they would go to another store (Walter and Grabner, 1975:59). Furthermore, from the analysis of the results, the researchers calculated that the expected monetary cost of an average single stockout situation was $1.26 (Walter and Grabner, 1975:58).

Brand Switching

One of the decisions consumers must make when faced with a stockout is whether or not to switch brands. Many studies have attempted to determine what causes consumers to switch brands. Researchers have analyzed response time, inflation, sales promotions, and brand loyalty in hopes of determining their effects on brand switching.

In a 1979 study, Tyebjee examined how brand conflict and product involvement affect the response time of a brand choice. He found that if one brand dominates other brands in the preference structure, choice time will be less than if the consumer has equal preferences (Tyebjee, 1979:302). He also hypothesized that the effect of brand preference structure on choice time would be moderated by a construct

termed "product involvement." This hypothesis, however, did not receive empirical support in the study (Tyebjee, 1979:302).

Jensen and Rao examined the changes in consumer behavior brought about by inflation. Because food items doubled in price during the 1970s, these authors focus their study on the purchase, preparation, and consumption of food items (Jensen and Rao, 1988:454). These researchers found that in food shopping, consumers reported an increased tendency to visit more stores, utilize coupons, develop shopping lists, reduce nonessential purchases, and buy lower priced items without reducing nutritional benefits (Jensen and Rao, 1988:467). Additionally, consumers reported switching brands, looking for specials, and purchasing in larger quantities as means of combating inflation (Jensen and Rao, 1988:467).

In a 1987 article, McAlister examined the profitability of sales promotions. This author reported that results of sales promotions are more drastic today because today's consumers are more willing to switch among products (McAlister, 1987:27). The researcher also stated consumers spend three to ten seconds in each product category, and, although they do not know the regular price of a chosen product, they do have a sense of whether or not the product is on promotion (McAlister, 1987:27). In the study,

McAlister classified consumers into eight segments ranging from those who are not promotion sensitive to those who only buy on promotion. Of the eight segments, three have conclusive results. The first two conclusive findings are that it is never profitable to promote to non-promotion sensitive consumers or to stockpiling consumers who do not switch brands for a promotion (McAlister, 1987:29). McAlister felt that these sales would have been made at the unpromoted margin, and, thus, promoting to these consumer segments merely decreases profits. The third result is that it is always profitable to promote to category expansion consumers. The profitability of the other six segments depends on the extent of the sales "bump."

Another study which looked at promotions' effects on brand switching is Gupta's 1988 study. By studying coffee promotions and sales, Gupta found that more than 84 percent of total sales increase due to promotion is accounted for by brand switching (Gupta, 1988:352). Purchase time acceleration accounts for less than 14 percent while stockpiling accounts for less than two percent of the total sales increase due to promotion (Gupta, 1988:352).

The final study addressed in this literature review is Wernerfelt's study on brand loyalty. The author attempted to develop a model which illustrates why a consumer remains loyal to a brand although he/she knows that another brand

has the same quality but at a lower price (Wernerfelt, 1985:381). Wernerfelt felt that through experience with a certain brand, consumers develop user skills which make the brand more useful to them than some other brand, although given the same experience with the other brand, the other brand would be equally useful (Wernerfelt, 1985:381). The brand utility of the researcher's model depends on three variables - the number of periods the current brand has been used, the price paid for the current brand, and a dichotomous variable which indicates whether or not the consumer searched for another brand during the same period (Wernerfelt, 1985:382). Wernerfelt found that the consumer will switch brands only if there is an adequately large price differential (Wernerfelt, 1985:384-385). This price differential, however, increases with the size of the user skills (Wernerfelt, 1985:385). The author also found that consumers eventually stop looking for other brands and that some consumers continue to buy at above-minimum prices (Wernerfelt, 1985:385).

This chapter focused on literature that discussed the relationship between inventory and customer service. As stated before, the goal of this research is to help the commissary increase its customer service without increasing its inventory carrying costs. With that goal in mind, techniques which decreased inventory without sacrificing

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customer service were reviewed. Surprisingly, some of these
techniques resulted in an increase in customer service
levels.

Additionally, the current customer service practices
of major firms were reviewed. The purpose of reviewing
these practices was twofold. First, they illustrate methods
of increasing customer service. Second, these practices
depict the increasing attention major firms are placing on
customer service.

Furthermore, the stockout decision tree was examined.
This tree represents the decision making process that
customers follow when confronted with a stockout. Finally,
articles which pertain to one aspect of the decision tree,
brand switching, were studied. These articles reveal that
inflation, sales promotions, and large price differentials
affect a shopper's brand decision.

The next chapter not only specifies the research plan
but also provides a detailed background on the Emmelhainz
and others research as well as the modeling techniques that
were reviewed.

III. Methodology

Introduction

The methodology of this research consists of five
sections. First, a background of the data collection will
be given. The second section contains a discussion of the
variables that will be used to provide solutions to the
investigative questions. In the third section, three
modeling techniques are researched, and the best model,
given the nature of the variables, is chosen. In the fourth
section, the statistical software that will be used to
analyze the data will be discussed. Finally, the fifth
section will discuss the research plan.

Background of Data

During a four day period in the summer of 1988,
Emmelhainz and others conducted research at the WPAFB
Commissary. The purpose of their study was twofold. First,
they intended to determine actual consumer reaction to out-
of-stock conditions where the stockouts were created
artificially, and, second, they wanted to identify the
factors which influence out-of-stock behavior (Emmelhainz
and others, undated:3).

The researchers, in cooperation with the commissary
management, selected five products with respect to a
specific brand, size, and variety to be actually removed

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from the store shelves. The stockout condition, however, did not include all brands, nor all sizes, nor all varieties of a product (Emmelhainz and others, undated:4). The five product groups chosen by the researchers were orange juice, coffee, peanut butter, tomato sauce, and toothpaste. These products were chosen after the review of commissary sales records and previous studies. They attempted to identify the products which had the highest chance of being sought by a customer on a typical shopping trip (Emmelhainz and others, undated:5). Additionally, the intent of the researchers was to identify products in which there were ample substitutes available to the shopper with respect to brand, size, and variety (Emmelhainz and others, undated:5).

After the products were selected, the researchers developed and tested a questionnaire which reflected the products and which was designed for in-store use. The survey instrument was also designed to be answered verbally by shoppers in only three to four minutes (Emmelhainz and others, undated:6). The survey included questions which addressed the intent to purchase the product category, the ability to find the desired item, the action taken if the product was not in-stock, the perceived product risk and brand loyalty, the intended product usage and urgency, the store patronage patterns, and, finally, demographics (Emmelhainz and others, undated:6).

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Once all preparations were completed, trained interviewers were stationed at the check-out lines (except for the express lines) to question shoppers as they waited to check-out. Over the four day period, 2,858 shoppers were asked to participate in the survey with 2,810 shoppers agreeing to participate. After agreeing to participate in the survey, shoppers were asked if they had intended to buy any of the five product categories. If they said yes, they were asked if they had been able to locate the exact brand, size, and variety for which they were looking. If they were unable to locate the exact product, they were asked a series of questions to determine the actions taken in place of purchasing the out-of-stock item. Questions were then asked on perceived risk of brand substitution, involvement, brand loyalty, commissary patronage and satisfaction levels, and demographics (Emmelhainz and others, undated:6-7). A copy of the survey may be seen in Appendix A while the initial results of their research may be seen in Appendix B.

Variables

Using the data accumulated by Emmelhainz and others, numerous models which predict consumer reaction to stockouts were developed. These models analyzed the consumer's reaction to stockouts using qualitative and quantitative variables. The variables were a result of questions

contained in the Emmelhainz and others consumer survey. In general, three variable groups - demographics, purchase situation, and shopper characteristics - were used to predict consumer behavior.

The investigative questions which addressed demographics used ten demographic variables in an attempt to predict consumer behavior. The variables were sex, age, education, household description, number of children, status of military member (active duty or retired), rank of military member, number of household incomes, household income, and the percent of household purchases for which the shopper was responsible. Six of these variables - sex, education, household description, status, rank, and household income - were qualitative and used categories to assign their respective values. The remaining variables - age, number of children, the number of incomes, and the percent of household purchases - were quantitative and were assigned the discrete values given in the survey responses. These variables and their data values may be seen in Table 1.

Purchase situations comprised the second group of variables and consisted of two qualitative variables. One of these variables refers to product usage while the urgency variable addressed the issue of whether the product is needed today. As with the previous variable groups, these

TABLE 1

INDEPENDENT VARIABLE TYPES AND VALUES

DEMOGRAPHIC

Variable	Type	Values
Sex	Nominal	Male = 1 Female = 2
Age	Ratio	1,2,..
Education	Ordinal	Less than High School = 1 High School Diploma = 2 Some College = 3 College Degree = 4 Some Graduate School = 5 Graduate Degree = 6
Household Description	Nominal	Single, No Children = 1 Single, Children at Home = 2 Single, Children not at Home = 3 Married, No Children = 4 Married, Children at Home = 5 Married, Children not at Home = 6
Number of Children	Ratio	0,1,..
Status	Nominal	Active = 1 Retired = 2
Rank	Interval	Unknown = 0 SMSgt = 8 Amn Basic = 1 CMSgt = 9 Amn = 2 Warrant = 10 A1C = 3 2nd Lt = 11 SRA = 4 1st Lt = 12 Sgt = 4 Captain = 13 SSgt = 5 Major = 14 TSgt = 6 Lt Col = 15 MSgt = 7 Colonel = 16

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TABLE 1 (Cont)

INDEPENDENT VARIABLE TYPES AND VALUES

DEMOGRAPHIC (Cont)

<u>Variable</u>	<u>Type</u>	<u>Values</u>
Rank (Cont)	Interval	Brig Gen = 17 Major Gen = 18 Lt Gen = 19 Gen = 20
Number of House- hold Incomes	Ratio	0,1,..
Annual House- hold Income	Ordinal	Less than $15,000 = 1 $15,000 - $19,999 = 2 $20,000 - $24,999 = 3 $25,000 - $29,999 = 4 $30,000 - $34,999 = 5 $35,000 - $39,999 = 6 $40,000 - $44,999 = 7 $45,000 - $49,999 = 8 $50,000 - $54,999 = 9 $55,000 - $59,999 = 10 Greater than $60,000 = 11
Shopper's Share of Household Purchases (%)	Ratio	0,1,..,100

PURCHASE SITUATIONS

Product Usage	Nominal	Regular = 1 Special = 2
Needed Today	Nominal	Yes = 1 No = 2

TABLE 1 (Cont)

INDEPENDENT VARIABLE TYPES AND VALUES

SHOPPER CHARACTERISTICS

Variable	Type	Values
Brand Repeats	Ratio	0,1,...,10
Brand	Ordinal	Weak = 1 Moderate = 2 Strong = 3
Product Risk	Ordinal	Low = 1 Medium = 2 High = 3
Commissary Satisfaction	Nominal	Satisfied = 1 Dissatisfied = 2 No Opinion = 3
Commissary Out-of-Stocks Compared to Other Stores	Nominal	More = 1 Same = 2 Less = 3
Typical Out-of-Stock Response	Nominal	Delay Purchase = 1 Special Trip = 2 Different Store = 3
Household Purchases at Comm (%)	Ratio	0,1,..,100

variables and their data values are listed in Table 1.

The final group of variables consisted of shopper characteristics. These seven variables reflected a number of issues ranging from brand loyalty to commissary

assessment, and, finally, to shopping behavior. In reference to the intentionally out-of-stock products, the first three variables measured the strength of brand loyalty. Brand repeats was a quantitative variable derived by asking the shoppers how many times (of the last ten purchases of the out-of-stock product) they purchased the same brand. Brand preference and the risk of using an unfamiliar brand were qualitative variables measured on three-point scales.

Two variables of the shopper characteristic group measured the shopper assessment of the commissary. Commissary satisfaction, a qualitative variable, gave a general rating of the commissary from the perspective of the shopper. The commissary out-of-stock variable compared the commissary to other stores on the number of times it is out-of-stock of items normally carried.

The remaining variables reflected typical shopping behavior. The not-available option was a qualitative variable which asked shoppers their typical response to an out-of-stock product. Finally, the "Percent Commissary" variable measured the percentage of household purchases made at the commissary. Theses variable and their values may be viewed in Table 1.

Models

As stated before, the objective of this research was to develop mathematical models that predict consumer behavior to out-of-stock situations using certain variables. To develop the desired models, three techniques were researched - standard multiple le. .t-squares regression, logistic regression, and discriminant analysis. Each of these techniques has inherent assumptions which must be satisfied prior to usage.

Multiple regression models are probabilistic models that allow for more than one independent variable or higher order terms. The purpose of this approach is to develop a model that minimizes the sum of squared errors (SSE). However, some assumptions must be made concerning the probability distribution of the random error components (epsilon) of these models. Least squares regression models assume the random error components are normally distributed with a mean of zero and a constant variance equal to the standard deviation (theta squared). Additionally, this type of model assumes the random error components are independent (McClave and Benson 1988:557,558). Furthermore, the typical application of least squares procedures usually involves the assumption that the dependent variable is some quantity that can be measured on a continuous scale (NH Analytical Software, 1987:5.63).

The dependent variables of the consumer decision tree for stockouts are either dichotomous or trichotomous. Problems are noted when standard multiple regression procedures are applied to situations when the dependent variable can only result in dichotomous or trichotomous values. In the case of the dependent variable resulting in dichotomous values, the condition of constant variance cannot hold because the response (dependent) variables will accept only a zero or a one as their solutions (Cox, 1970:16). Additionally, since the response variables are not normally distributed because of their dichotomy, standard distributional statements for estimators do not apply (Agresti, 1984:105). Because of some of the explanatory (independent) variables being quantitative, the standard multiple regression approach will result in using a model which will predict expected values less than zero and greater than one. These values which are impossible due to the dichotomy of the response variables will result from sufficiently small or sufficiently large values of the quantitative variables (Agresti, 1984:105). These limitations of applying standard multiple regression procedures to dichotomous dependent variables also apply to trichotomous dependent variables.

In response to the difficulties involved in using standard multiple regression procedures, alternative

modeling techniques were researched. Logistic regression uses categorical or continuous explanatory variables to determine the value of a dichotomous response variable. Logistic regression is used when it is of interest to examine how observed proportions or rates depend on particular independent variables. It examines the relationship between the logistic transformation of the proportions and linear combinations of the predictor variables (NH Analytical Software, 1987:5.34).

Because logistic regression determines the predicted proportion of success, it was inappropriate and was, therefore, rejected, and discriminant analysis was researched.

Discriminant analysis is a multivariate technique whose goal is to predict membership in groups from a set of independent variables (Tabachnick and Fidell, 1989:26). It identifies the relationship between qualitative criterion variables (dependent variables) and quantitative predictor variables (independent variables) and classifies an object into one of the criterion variable groups through the use of a weighted combination of predictor variable values (Kachigan, 1986:357,360).

As with the two other modeling techniques, there are, however, certain prerequisites and assumptions that precede the use of discriminant analysis. Klecka identified seven

key assumptions. First, two or more mutually exclusive groups must exist and are presumed to differ on several variables (Klecka, 1980:8). Second, there must be at least two cases per group (Klecka, 1980:11). Third, the only limit to the number of discriminating variables is that the number of cases must exceed the number of variables by more than two (Klecka, 1980:9). The fourth assumption requires the discriminating variables to be measured at the interval level (Klecka, 1980:11). Fifth, certain mathematical requirements of the technique prohibit a variable being a linear combination of other discriminating variables (Klecka, 1980:9). Sixth, the within-group population covariance matrices are required to be approximately equal (Klecka, 1980:9). Finally, each group must be drawn from a population which has a multivariate normal distribution on the discriminating variables (Klecka, 1980:10).

In addition to the assumptions listed above, other authors have specified further assumptions. Kachigan requires that every object be measured on the same set of predictor variables, however, the number of objects in each group need not be the same (Kachigan, 1986:359). Tabachnick and Fidell assume the sample size of the smallest group should exceed the number of predictor variables (Tabachnick and Fidell, 1989:511). These two authors also stated discriminant analysis is robust to two of Klecka's seven

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assumptions. According to Tabachnick and Fidell, discriminant analysis is robust to the normality assumption if the violation is caused by skewness rather than outliers (Tabachnick and Fidell, 1989:511). Additionally, discriminant analysis is robust to the "equal within group variance-covariance matrices" assumption when the sample sizes are equal or large. However, when sample sizes are unequal and small, significance testing may be misleading if there is heterogeneity of the variance-covariance matrices (Tabachnick and Fidell, 1989:511-512).

With regard to the data of this study, each model used the same set of predictor variables to classify the observations into mutually exclusive criterion groups. Of the seven sample sets which were used to generate all of the models, the smallest sample size was 76. The sizes of the sample sets resulted in Klecka's second and third assumptions being met. The sample sizes also allowed the Multivariate Central Limit Theorem to be used to assume the population has a multivariate normal distribution (Johnson and Wichern, 1988:145 and Reynolds Interview, 1990). Additionally, the large sample sizes were a basis for assuming there was homogeneity of the variance-covariance matrices (Tabachnick and Fidell, 1989:512). Because none of the variables were a linear combination of other

discriminating variables, the data met Klecka's fifth assumption.

The one remaining assumption yet to be addressed is Klecka's fourth assumption which states the discriminating variables should be either interval or ratio. As may be seen in Table 1, few of the discriminating variables are interval or ratio. However, because the objective of this study was to use the Emmelhainz and others survey data to develop the models, this research will continue using the existing variables. Although, Klecka stated that violation of the assumptions could have a negative effective on the accuracy of the discriminant analysis (Klecka, 1980:63).

Discriminant analysis begins with a set of observations whose group memberships are known and uses the initial set of data to fit a relationship which can subsequently be used to classify other observations whose group memberships are not known (Jackson, 1983:89). This relationship is called a discriminant function and is of the form

$$D_i = d_{i1}Z_1 + d_{i2}Z_2 + \ldots + d_{ip}Z_p$$

where D_i is the score on the discriminant function "i," the "d's" are weighting coefficients, and the "z's" are the standardized values of the "p" discriminating variables used in the analysis (Klecka, 1975:435). The reason two sets of

data are typically used in discriminant analysis is to reduce the bias. If the same set is used to define the discriminant function and to evaluate the function, the resulting error-count has an optimistic bias (SAS/STAT User's Guide, Volume 1, 1989:685).

Software

Although there are many statistical packages currently available that have discriminant analysis capability, SAS was chosen for two primary reasons. First, SAS offers many different options with respect to analysis and output. Author familiarity with SAS is the second reason.

With respect to analysis, SAS offers both parametric and nonparametric methods that can be used to derive classification criteria. Nonparametric methods can be used when the distribution within each group is not assumed to have any specific distribution or is assumed to have a distribution different from the multivariate normal distribution (SAS/STAT User's Guide, Volume 1, 1989:46). Other options offered by SAS that may be needed for this research are the ability to specify the prior probabilities of group membership and the posterior probability error-rate estimates of the classification criteria. Prior probabilities are used for other than equal or proportional priors and allow the user to specify the prior probability

for each level of the classification variable (SAS/STAT User's Guide, Volume 1, 1989:694). The final SAS option desired for this research was the stepwise discriminant analysis procedure. This procedure was only used to solve the fourth investigative question.

Because it was assumed the population had a multivariate normal population, this research used the parametric method to develop all of the models. Furthermore, equal prior probabilities were used since they allow for maximum separation of the dependent groups (Johnson and Wichern, 1988:487).

With regard to missing values, SAS excludes those observations with missing values from the development of the discriminant function (SAS/STAT User's Guide, Volume 1, 1989:696). The observations with missing independent variables values were completely disregarded. Although those observations which were missing only dependent variable values were classified in a separate section of the classification table, they were not included in the analysis because there was no way to compare the actual value with the predicted value.

Research Plan

The research plan was tailored to answer each of the investigative questions of this study. This plan resulted

in the development of several models using seven sample
sets. Investigative questions one through five as well as
seven and eight were addressed using the sample set which
consisted of the 375 shoppers who intended to purchase any
of the five products that were purposely out-of-stock but
could not find the specific product they sought (with regard
to brand, size, and variety). This sample was then
separated into five subsets - one for each of the five
products - for investigative question six.

The solution to the first investigative question used
the larger sample set and the demographic variable group to
develop a model for each of the decision nodes of the
stockout response decision tree (i.e. substitution decision
and the brand, size, and variety of the substituted
product). The decision nodes were regarded as the dependent
variables while the demographic variables were the
independent variables.

In addressing the second research question, the
purchase situations variable group was used to develop four
models (one for each of the decision nodes) while the
shopper characteristics group was used for the models of the
third question. In all of these models, the decision ncdes
were the dependent variables while the independent variables
were comprised of the respective variable group.

The fourth investigative question was addressed through

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the use of stepwise discriminant analysis. This procedure was used to evaluate the demographic variable group at the .05 level of significance to determine if sex, age, status, and/or rank were significant predictors of the decision nodes.

Investigative question five was resolved using five different sample sets - one sample set for each of the intentionally out-of-stock products. A total of sixteen models were developed from each of the samples. A model was developed for each of four decision nodes using each of the four variable groups. For example, using a sample set derived from those shoppers who intended to purchase orange juice and using the demographic variable group, models were developed which predicted the substitute decision node, the brand of the substitute product, the size of the substitute, and the variety of the substitute.

The sixth investigative question was addressed using the entire survey population (all 2,810 survey responses). However, only one model was developed. As a general out-of-stock model, this model was intended to predict the typical reaction to an out-of-stock condition. Therefore, using the demographic variable group (minus the number of children variable), a model was developed which predicted the not-available-option variable, a trichotomous variable that measured the shopper's typical reaction to an out-of-stock

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condition. The number of children at home variable was not used because that question was not listed in the survey (Appendix A). For the sample set containing 375 cases, the number of children at home was attained by counting the number of entries to the survey question which asked the ages of the children at home.

As stated before, all of the previous models were built using only one data set to define the discriminant function and for classification. Investigative questions seven and eight required the sample to be separated into two data sets. All observations were sequentially numbered 1 to 375. The odd numbered observations were placed in one data set while the even numbered observations were placed in another set. By separating the sample in this manner, it was hoped each data set would be equally influenced by the weekend shoppers and the weekday shoppers.

The first data set was used to develop the models that predict the observations of the second data set. The larger sample set (n=375) was chosen because the number of observations were large enough that none of the assumptions that pertain to group sample size were violated.

The intent of the seventh investigative question was to measure the effectiveness of models built from half of the data to predict the other half of the data. Meanwhile, the eighth investigative question required the results of the

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previous question to be compared to the results of the first three investigative questions. The results of the models developed for the seventh question, however, were not expected to be superior to the results of the models of the first three questions because the bias of the models using the undivided sample sets would result in an overestimation of the power of the classification procedure (Klecka, 1980:51). In the case of discriminant analysis, bias results from the observations that are to be classified influencing the discriminant functions. Therefore, the correct rate of the models using the divided sample sets should be less than the models using the undivided sample sets.

After all of the models were developed, they were evaluated on their effectiveness. The models' effectiveness was determined by their ability to correctly classify the observation. With regard to the desired "correct rate," the two sources that were reviewed had differing opinions. In his 1988 dissertation, Materna used discriminant analysis and stated the desired confidence level of his study was 90 percent (Materna, 1988:102). Tabachnick and Fidell, on the other hand, did not specify an acceptable confidence level but stated the percent correct should be substantially larger than the percent expected correct by chance alone if the models are to be considered useful (Tabachnick and

Fidell, 1989:544). For the purposes of this study, a correct rate of 90 percent is desired, however, those models that provide a correct rate of at least 80 percent will be considered useful.

In summary, this chapter presented a background of the data collection, a description of the variables, a review of the modeling techniques that were researched, and an assessment of the software that was used. Additionally, the research plan of this study was discussed. The next chapter will examine the results of each of the investigative questions.

IV. Analysis

Introduction

This chapter is divided into nine sections corresponding to the eight investigative questions discussed in the preceding chapters and a summary section. The first three sections discuss the results of the discriminant analysis models and their ability to predict the decisions of the larger sample set of 375 with regard to substitution, brand, size, and variety. The fourth section examines the results of the stepwise discriminant analysis model.

The fifth section addresses the investigative question of developing models for a specific product. This section is divided into five subsections corresponding to the five products that were removed from the shelves - orange juice, coffee, peanut butter, tomato sauce, and toothpaste. The sixth section discusses the general out-of-stock model. The two investigative questions requiring divided sample sets are then addressed. Finally, the last section provides a brief summary of the chapter.

Investigative Question #1

This question addresses the ability of the ten demographic variables to predict out-of-stock behavior. As may be seen in Table 2, these models were not useful in their ability to predict the behavior of the 375 customers

since the highest correct rate of these four models was 61.9 percent.

TABLE 2

CORRECT RATES OF LARGER SAMPLE SET MODELS

| | INDEPENDENT VARIABLE GROUPS | | |
DEP VAR	DEMO	PURCH SIT'N	SHOPPER CHAR
SUBSTITUTION	56.9697%	62.8415%	64.0805%
BRAND	61.8852%	57.6208%	60.0000%
SIZE	42.8571%	23.2824%	49.3976%
VARIETY	61.9048%	58.3333%	57.2614%

Although the sample set began with 375 observations, the models did not use the total sample size for two rea-ons. The first reason was due to missing data values. Second, only those observations which decided to substitute could be used in the brand, size, and variety models. For example, 330 observations were used in developing the substitute model. Of these observations, 243 actually decided to substitute. Finally, of the 243 that substituted, 231 observations were used to develop the model of the final decision - the variety model.

The model developed to predict the substitute - do not substitute decision was able to correctly classify approximately 57 percent of the 330 observations. With respect to the brand and variety of the substitute product,

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the demographic variables were only able to correctly predict 61.9 percent of the observations. Finally, the most disappointing result occurred while attempting to predict the size of the substitute product. Only 42.9 percent of the 231 observations were correctly classified.

Of these four models, the variety model had the highest correct rate (61.9 percent). 231 observations were used to develop this model of which 139 actually chose the same variety while 92 chose a different variety. This model correctly classified 90 of the 139 observations that chose the same variety and 53 of the 92 that chose a different variety. The discriminant functions for this model were as follows:

$$D_{same} = -65.65163 + .36732*PERSBUY + 9.32301*SEX + .22186*AGE$$
$$+ 5.9082*EDUC + 5.80959*HSEHLD + 7.20281*DUTYSTAT$$
$$+ .46864*RANK + 7.83929*NUMINC - 1.01*ANNLINC$$
$$+ 2.45543*NUMCHILD$$

$$D_{diff} = -66.11311 + .36039*PERSBUY + 9.07205*SEX + .23661*AGE$$
$$+ 5.85084*EDUC + 5.69494*HSEHLD + 6.90163*DUTYSTAT$$
$$+ .52080*RANK + 8.80461*NUMINC - 1.06054*ANNLINC$$
$$+ 2.79563*NUMCHILD$$

Investigative Question #2

Using only two independent variables, the models derived from using purchase situation variables to predict

out-of-stock behavior provided insignificant results. Of these four models, only one model - the substitution model - had better results than its respective demographic model.

Furthermore, the substitute decision model had the best results of these four models as it was able to correctly classify 62.8 percent of the 366 cases (See Table 2). The brand and variety models did not fare as well as they correctly classified 57.6 percent and 58.3 percent of the observations, respectively. Once again, the model developed to predict the size of the substitute product proved to be the weakest with a mere 23 percent correct rate.

The substitute model correctly classified 155 of the 269 observations that actually chose a substitute product and 75 of the 97 that did not choose a substitute product. The discriminant functions for this model were as follows:

$$D_{sub} = -19.27667 + 28.00155*USAGE + 7.04597*NDTODAY$$
$$D_{notsub} = -23.75085 + 30.12859*USAGE + 8.46727*NDTODAY$$

Investigative Question #3

These models were developed from the seven shopper characteristic variables. Of the models developed from the larger set, these variables had the best models for predicting substitution and size. Once again, the substitute decision had the best performance with 64.1 percent of the 348 observations correctly classified (See

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Table 2). The brand model had the next highest margin of correct classifications. This model correctly classified 60.0 percent of the 255 observations. The variety model did not perform quite as well with a 57.3 percent correct rate. Finally, the size model correctly classified 49.4 percent of the 262 observations. Although, this model was still well below the desired confidence level, it was better able to predict the size of the substitute product than the models of the two previous investigative questions.

The substitute model correctly classified 165 of the 255 observations that actually chose a substitute product, and 58 of the 93 that did not substitute. The discriminant functions for this model were as follows:

$$D_{sub} = -31.77493 + .27492*BRNDREP + 7.03753*BRNDPREF$$
$$+ 2.01421*PRODRISK + 13.65003*COMMSAT$$
$$+ 3.63655*COMMOUT + 2.27797*NTAVLOPT$$
$$+ .17281*PERCOMM$$

$$D_{notsub} = -32.78292 + .19039*BRNDREP + 7.60629*BRNDPREF$$
$$+ 2.45628*PRODRISK + 13.39444*COMMSAT$$
$$+ 3.73051*COMMOUT + 2.029*NTAVLOPT$$
$$+ .17125*PERCOMM$$

In general, the demographic, purchase situations, and shopper characteristics variable groups were unable to significantly classify the observations. As seen in Table

2, the correct rates of these variables groups with respect
to the substitution, brand, and variety models seemed to
cluster around 60 percent. The size models were far more
disappointing.

Investigative Question #4

This investigative question was addressed using a
different SAS procedure than were the other investigative
questions. The stepwise discriminant analysis procedure was
used to determine which demographic variables were
significant in predicting the four dependent variables.
Using F-tests with significance levels for entry and removal
equal to .05, none of the demographic variables were
selected for the substitution and size models. Two
variables, however, were selected for the brand and variety
models. Rank and the number of household incomes were
selected for the brand model while the number of incomes and
the number of children living at home were selected for the
variety model.

Using only the selected variables, models were
developed for brand and variety. Number of incomes and rank
were able to correctly classify 54.3 percent of the 265
brand decisions. Number of incomes and number of children
correctly classified 58.4 percent of the 255 variety
observations.

Once again, the results of these models were far below the desired and the useful levels. However, in the case of the variety model, the correct rate of 58.4 percent approximates the 61.9 percent of the model developed from all ten demographic variables (See Table 2). These results illustrate that approximately the same correct rate can be obtained with fewer variables.

Investigative Question #5

By dividing the larger sample set into the five products, models were developed for each product to predict substitution, brand, size, and variety. Although all of these models produced insignificant results, their correct rate, in general, was much improved over the rate of the models which used the larger sample set.

Orange Juice. Orange juice was the first product for which models were developed. Immediately, better results were obtained as all of the models had larger correct rates than their counterparts that used the larger sample set.

Of the models which used demographic variables, the model that predicted variety correctly classified 79.2 percent of the 48 observations. Substitution, brand, and size were next in order with correct rates of 74.6 percent, 66.7 percent, and 58.8 percent, respectively (See Table 3).

TABLE 3

CORRECT RATES OF ORANGE JUICE MODELS

| | INDEPENDENT VARIABLE GROUPS | | |
DEP VAR	DEMO	PURCH SIT'N	SHOPPER CHAR
SUBSTITUTION	74.6032%	70.6667%	73.2394%
BRAND	66.6667%	60.3448%	69.0909%
SIZE	58.8235%	56.8966%	47.2727%
VARIETY	79.1667%	72.2222%	64.7059%

The order of the individual models for the purchase situation variables was the same as that of the demographic variables - variety, substitution, brand, and size - with respect to the percents of correctly classified observations. The difference, however, was that for all four dependent variables the percentage of correctly classified observations were lower than the models that used demographic variables.

The descending order of model effectiveness for the shopper characteristic models was different from the order of the other two variable groups in that the substitution model was the most effective with the brand, variety, and size models following.

Coffee. Although the coffee models were insignificant, two important points should be noted. First, of the five products, the demographic model with substitution as a dependent variable had the highest percentage (75 percent)

of correctly classified observations (See Table 4).
Although this model was not determined to be useful by the
criteria of this research, management may conclude that
being able to predict the substitute decision of three out
of four shoppers is useful.

TABLE 4

CORRECT RATES OF COFFEE MODELS

| DEP VAR | INDEPENDENT VARIABLE GROUPS | | |
	DEMO	PURCH SIT'N	SHOPPER CHAR
SUBSTITUTION	75.0000%	70.1149%	72.8395%
BRAND	74.1379%	53.1250%	71.1864%
SIZE	65.4545%	35.0000%	42.1053%
VARIETY	65.4545%	56.6667%	63.1579%

Second, the demographics-size model was the first size
model reviewed thus far that had a correct rate equal to or
greater than the correct rate of another model within the
variable group. In this instance, the effectiveness of the
demographics-size model (65.45 percent) equaled that of the
demographics-variety model. The purchase situation and
shopper characteristic variables, however, were ineffective
in predicting size.

Peanut Butter. The peanut butter models had five of
the most effective models. Within the demographic group,
the variety models correctly classified 83.8 percent of the
37 observations which, by the way, was the highest correct

rate of any model developed during this research. This model correctly classified 28 of the 32 observations that actually purchased the same variety and 3 of the 5 observations that purchased a different variety. The discriminant functions for this model are as follows:

$$D_{same} = -87.37504 + .8364*PERSBUY - 3.02545*SEX +.42748*AGE$$
$$+ 14.37768*EDUC + 5.57488*HSEHLD + 9.02799*DUTYSTAT$$
$$+ .55074*RANK + 6.56823*NUMINC - 3.27652*ANNLINC$$
$$+ 4.43261*NUMCHILD$$

$$D_{diff} = -82.22683 + .76386*PERSBUY - 2.02499*SEX + .3753*AGE$$
$$+ 14.04567*EDUC + 5.0366*HSEHLD + 7.49786*DUTYSTAT$$
$$+ .75223*RANK + 7.7229*NUMINC - 2.78209*ANNLINC$$
$$+ 4.68964*NUMCHILD$$

Furthermore, of all of the brand models, this demographics-brand model had the highest percentage of correct classifications by effectively classifying 77.5 percent of the 40 observations. It correctly predicted 20 of the 27 observations that chose a substitute product of the same brand and 11 of the 13 that chose a different brand.

Within the shopper characteristic group, this product had three models that had the highest correct rate of the five products. The brand model effectively classified 76.2 percent of the observations. Furthermore, the variety model

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had a correct rate of 74.4 percent while the size model was of 66.7 percent effective.

TABLE 5

CORRECT RATES OF PEANUT BUTTER MODELS

DEP VAR	INDEPENDENT VARIABLE GROUPS		
	DEMO	PURCH SIT'N	SHOPPER CHAR
SUBSTITUTION	64.0000%	65.4545%	75.0000%
BRAND	77.5000%	59.0909%	76.1905%
SIZE	60.0000%	34.0909%	66.6667%
VARIETY	83.7838%	55.0000%	74.3590%

Tomato Sauce. Two important observations were noted from the tomato sauce models. First, concerning all of the shopper characteristics models developed to predict the substitution decision, this model was the most effective. As may be seen in Table 6, this useful model correctly classified 81.5 percent of the 54 observations. It correctly predicted 36 of the 40 observations that actually substituted and 8 of the 14 that did not substitute.

Second, this sample set produced another useful model. Having a correct rate of 81.6 percent, the demographics-variety model correctly classified 31 of the 38 observations. This model correc''y predicted 16 of the 19 observations that chose a substitute product of the same variety and 15 of the 19 that chose a different variety.

TABLE 6

CORRECT RATES OF TOMATO SAUCE MODELS

INDEPENDENT VARIABLE GROUPS

DEP VAR	DEMO	PURCH SIT'N	SHOPPER CHAR
SUBSTITUTION	61.8182%	51.7857%	81.4815%
BRAND	67.5000%	56.0976%	58.9744%
SIZE	64.1026%	40.0000%	59.4595%
VARIETY	81.5789%	60.5263%	63.8889%

Toothpaste. The toothpaste models had one distinguishing observation. Of all of the models that predict the size of the substitute product, the demographics-size model was the most effective with a 67.9 percent correct rate. This model correctly classified 30 of the 42 observations that actually chose a substitute product of the same size, 3 of the 6 that chose a substitute of a smaller size, and 3 of the 5 that chose a larger size.

In general, for the five products, five general points of interest were noted. First, the effectiveness of the variable groups to predict the four dependent variables varied by product. Second, in all cases, the size model was the least effective of the purchase situation variables. Third, for each of the five products, the demographic variable group was the best predictor of the variety decision. Fourth, except for the orange juice models,

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TABLE 7

CORRECT RATES OF TOOTHPASTE MODELS

| DEP VAR | INDEPENDENT VARIABLE GROUPS | | |
	DEMO	PURCH SIT'N	SHOPPER CHAR
SUBSTITUTION	54.8780%	58.0645%	68.8889%
BRAND	74.5455%	59.6774%	60.0000%
SIZE	67.9245%	16.6667%	62.0690%
VARIETY	75.4717%	53.3333%	65.5172%

demographics provided the best predictors of the brand decision. Finally, excluding the peanut butter models, demographics were the best predictor of size.

As may be seen, using the product specific data sets, demographics appears to provide the best predictors for three of the four decision nodes. The decision to substitute, however, had mixed results as demographics provided the best results for orange juice and coffee while shopper characteristics were the better protectors for the remaining products.

Investigative Question #6

The best method for deriving a general out-of-stock model for multiple products was to use the entire survey population (n = 2,810). From this sample set, a model was derived using the demographic variable group (minus the number of children variable) to predict the shopper's usual

reaction to an out-of-stock condition. This dependent variable is of a nominal type and has three possible values - go to another store, buy at the commissary later, or substitute another item.

This model correctly classified 39 percent of the 1,816 observations. This correct rate was far from the desired 90 percent confidence level and the 80 percent useful level. The model's effectiveness was more in tune with the results of the size models from the previous investigative questions and suggests one conclusion. Because the results of this model were just a little better than chance (33 percent), it appears the demographics variables were unable to distinctly classify a shopper's typical response to an out-of-stock condition. In other words, shoppers of different demographics do not necessarily have different responses to a stockout.

Investigative Questions #7 and #8

The seventh investigative question required the use of half of the data to develop the models that classify the observations of the other half. In this manner, models with reduced bias could be analyzed since the same data were not used for both model building and classifying.

In addressing this question as well as the next, four models were chosen using the larger sample set (n = 375).

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In reference to Table 2, the demographic variable group provided the best models for predicting the brand and variety of the substitute products while the shopper characteristics provided the best models for the substitute decision and the size of the substitute product. Therefore, four models were developed - demographics-brand, demographics-variety, shopper characteristics-substitute, and shopper characteristics-size.

As may be seen from Table 8, the demographics-variety model provided the best results. This model correctly classified 53.9 percent of the 115 observations. The demographic-brand and shopper characteristics-substitute models were next in order with correct rates of 53.2 percent and 51.7 percent, respectively. Once again, the size model (shopper characteristics-size) had the worst results with a 34.4 percent correct rate.

Investigative question eight examined the results of the seventh question and compared them to the results of the corresponding models of the first and third investigative questions. There were no surprises as the models from the undivided sample sets had greater correct rates than the reduced bias models (those developed from the divided sample set). As may be seen from Table 9, the size models had the greatest differences as the model developed from the undivided samples set had a correct rate that was almost 15

TABLE 8

CORRECT RATES OF REDUCED BIAS MODELS

INDEPENDENT VARIABLE GROUPS

DEP VAR	DEMO	SHOPPER CHAR
SUBSTITUTION	-------	51.7241%
BRAND	53.2258%	-------
SIZE	-------	34.4000%
VARIETY	53.9130%	-------

percent better than the reduced bias model. Meanwhile, the smallest differences occurred in the variety models as the larger sample set model had a correct rate that was approximately 8 percent better than the reduced bias model.

TABLE 9

UNDIVIDED SAMPLE SET VS. REDUCED BIAS MODELS

INDEPENDENT VARIABLE GROUPS

DEP VAR	DEMOGRAPHICS		SHOPPER CHAR	
	UNDIVIDED SAMPLE	DIVIDED SAMPLE	UNDIVIDED SAMPLE	DIVIDED SAMPLE
SUBSTIT	-------	-------	64.0805%	51.7241%
BRAND	61.8852%	53.2258%	-------	-------
SIZE	-------	-------	49.3976%	34.4000%
VARIETY	61.9048%	53.9130%	-------	-------

Summary

The results of this analysis were presented in this chapter. The next chapter, ·apter V, Conclusions and

Recommendations, will use these results to develop
conclusions and make recommendations for future research and
appropriate management action.

V. Conclusions and Recommendations

Introduction

The intent of this research was to measure how effective certain independent variable groups were in predicting consumer reactions to stockouts. It was hoped these variables would be accurate so the models could be provided to commissary management. Commissary management could then use the models to predict whether certain consumer groups would substitute as well as the brand, size, and variety of the substitute product. The goal was to help the commissary reduce inventory carrying costs and lost sales due to stockouts.

This chapter is comprised of three sections. The conclusions of the research are discussed in the first section. The second section provides recommendations for future research while the third section suggests other recommendations as noted throughout the study to improve customer service.

Conclusions

Using the larger sample set, the models of the first three investigative questions were not determined to be useful in predicting consumer reactions to stockouts as the highest correct rate of classification was 64.1 percent (shopper characteristics-substitution model). The lack of

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usefulness for these multi-product models can, apparently, be attributed to the inability of demographics, purchase situations, and shopper characteristics to correctly classify shoppers. In general, shoppers having different demographics appear to have been making the same decisions. The same can be said for the other two variable types.

However, when the models became product specific, the ability of the three variable types to correctly classify shoppers increased. Of the sixty models that were developed for the five products, only twelve had correct rates that were less than their counterparts which were developed from the larger sample set. Furthermore, in the case of the demographic-variety models, there was almost a 20 percent differential between the results of the peanut butter model and the results of the larger sample set. These findings emphasize that in order to maximize the effectiveness of stockout models the models should be product specific.

Additionally, the three models that were determined to be useful were product specific. The peanut butter demographics-variety model correctly predicted 83.8 percent of its observations. The other two useful models were developed from the tomato sauce sample set. The demographics-variety model had a correct rate of 81.6 percent while the shopper characteristics-substitution model had a correct rate of 81.5 percent.

However, unlike models developed from demographics, the shopper characteristics models may be severely limited in their usefulness. Variables such as brand repeats, brand preference, and product risk are likely to be product specific. Therefore, in order to develop models from these variables, the commissary (and other retailers) and manufacturers will need to survey their customers to determine their shopper characteristics with respect to all products for which they want to develop models. The costs of these surveys could be enormous.

Meanwhile, the models developed from purchase situation variables were purchase specific. For a given shopper, these variables are likely to be different on each shopping trip. Furthermore, this variable group typically provided the worst results of the three variable types. Therefore, this study suggests that time and money should not be invested in developing models from this variable type.

Since models developed from shopper characteristics may be extremely expensive to obtain and models developed from purchase situations are likely to provide insignificant results, emphasis should be placed on developing models from demographics for two reasons. First, given the same retailer, the same demographic survey results can be applied to models developed for different products. Second, this

variable type typically provided some of the best predictive results.

For each of the five products, the demographic model provided the best results for at least two of the four decisions. However, like the other variable types, the demographic models were unable to provide significant results with respect to size. Meanwhile, with the exception of the coffee models, the demographic model with the best results was the variety model.

The other two decisions - substitution and brand - provided mixed results. Although, the brand models typically provided better results than the substitution models. The usefulness of these two models is dependent upon the business type (manufacturer vs. retailer). While the commissary and other retailers may be more concerned about predicting shoppers who do not substitute and go to another store, manufacturers may be more concerned with predicting those shoppers who switch brands. However, since the effectiveness of these two models is questionable at this point, the commissary should focus on developing variety models.

The stepwise discriminant models developed to address the fourth investigative question did not provide the conclusions that were hoped. It was hoped that rank and duty status would be selected because the base demographics

with respect to these variables are available through the base personnel offices. Base demographics with respect to sex and age are also available. The Emmelhainz and others survey data reflect the sex and age of the shopper. However, it was not known whether the shopper was a military member or a dependent.

These models do, however, illustrate that approximately the same results can be obtained with fewer variables. Although these models may not have results equal to the models developed from all ten demographic variables, it may be more cost effective to use the results of the stepwise models if it is significantly more expensive to attain the data necessary for the larger models. However, one possible limitation not addressed by this research is that the stepwise models may be product specific.

The final two research questions illustrate the extent to which the correct rate of a model decreases as bias is reduced. In the case of the size and substitute models, the effectiveness decreased by over ten percent while the effectiveness of the brand and variety models decreased by approximately eight percent. These results illustrate that the "true correct rate" of the product specific models that were determined to be useful may, in fact, be less than 80 percent because of the bias that was introduced by classifying the same data upon which the models were built.

Recommendations for Future Research

It is recommended that research be conducted on three areas. First, the true effectiveness of the product specific demographic models should be determined. However, the research can only be accomplished by increasing the sample size for each product. Each product's sample size should be large enough that none of the group sample size assumptions will be violated. The study will determine whether some of the product specific demographic models are, indeed, useful.

If some of the models are determined to be useful, commissary management can use the models when stockouts occur to predict shopper reactions. By providing substitute products having the attributes as determined by the models (i.e. same brand, smaller size, or same variety), management may be able to decrease lost sales that result from stockouts. Furthermore, since management will know which substitute product to maintain in inventory, they may be able to decrease inventory by eliminating those products having the attributes that rarely result from using the models.

Using either the Emmelhainz and others survey data or the data acquired from the previous paragraph, product specific stepwise models should be developed. The stepwise research has two objectives. First, it will determine

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whether stepwise models are indeed product specific. In other words, the study will determine whether different products have the same stepwise predictor variables. Second, the analysis will determine the effectiveness of the stepwise models. Since this study has shown that stepwise models provide approximately the same results as the fuller models, management may determine it is more cost effective to use the stepwise models.

The final area of suggested research involves developing models that predict actions based upon multiple characteristics of the model. As an example, predicting the variety and size or the brand and variety of the substitute product may be more useful than predicting a single attribute of the substitute product. In this manner, the commissary management can focus their attention on a more narrow set of possible substitutes.

Using demographic variables, preliminary investigation of predicting a substitute product that has two attributes that are the same as those of the original product yielded a 59.2 percent correct rate. Nevertheless, further study of predicting multiple attributes of a product should be done.

Recommendations for Management

In conclusion, management should attempt to improve customer service using three methods. First, product

specific variety models should be developed using demographic variables. As stated earlier in this research, customer service can be improved by either increasing the inventory of a single product or the inventory of the overall selection. Based upon this research, variety models should provide useful results in predicting the variety attribute of the substitute products. Knowing which variety to maintain, commissary management can increase customer service by increasing the inventory of products having the correct variety as determined by the model.

Although this research suggests that size models be avoided, brand and substitute models may also provide useful results depending on the product. The ability to accurately predict the brand of the substitute products will also result in an improvement in customer service.

Since this research suggests there is no structured method of predicting size given the three variable types derived from the Emmelhainz and others survey data, manufacturers and retailers should determine the impact of reducing the number of different sizes. Instead of providing three or more sizes, management may determine it is more profitable to provide two sizes. By reducing the number of sizes to two, some of the "sludge" may be removed, thus, allowing more shelf space for faster moving sizes.

Appendix A: Emmelhainz and Others Shopper Survey

1. Would you be willing to answer a few questions about your shopping experience today in order to help the commissary provide better service to you?

YES   NO

2a. Did you INTEND TO BUY any of the following products when you arrived at the Commissary?

2b. For any of these products, was the specific item you wanted unavailable (i.e., not on the shelf)?

YES	NO	frozen orange juice	AVAILABLE	NOT AVAILABLE
YES	NO	ground coffee	AVAILABLE	NOT AVAILABLE
YES	NO	peanut butter	AVAILABLE	NOT AVAILABLE
YES	NO	tomato sauce	AVAILABLE	NOT AVAILABLE
YES	NO	toothpaste	AVAILABLE	NOT AVAILABLE

[COMPLETE THIS SECTION FOR ANY ITEM MENTIONED IN 2b AS NOT BEING AVAILABLE]

3a._____

Did you buy something else instead?

YES   NO

If YES, what did you buy?

	BRAND	SIZE	VARIETY	DIFFERENT PRODUCT
	Same	Same	Same	
(Circle response)	Different	Larger Smaller	Different	

If NO, will you: delay the purchase until your next regular trip to the Commissary

(Circle response)   make a special trip back to the Commissary for the item at a later time

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make a trip to a different
                    store for the item

4. Were you buying this product for:

regular usage   special occasion

5a. Did you have to buy this product today?

YES   NO

5b. If not today, do you need it before your next scheduled
shopping trip?

YES   NO

6. How many times out fo the last 10, have you bought the
same brand of this product?

_____ times

7. What is your preference for the brand you buy most often?

weak   moderate   strong

8. Overall, how risky do you think it would be to buy an
unfamiliar brand of this product?

low   medium   high
_____
3b. Was there any item you intended to buy today that you
did not find available?

_____(Enter Product Here)

Did you buy something else in place of the item you wanted?

YES   NO

If YES, what did you buy?

                    BRAND   SIZE   VARIETY   DIFFERENT
                                                    PRODUCT
                    Same   Same   Same

(Circle   Different   Larger   Different
response)   Smaller

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If NO, will you: delay the purchase until your next
regular trip to the Commissary

(Circle   make a special trip back to the
response)   Commissary for the item at a later
time

make a trip to a different store
for the item

4. Were you buying this product for:

regular usage   special occasion

5a. Did you have to buy this product today?

YES   NO

5b. If not today, do you need it before your next scheduled
shopping trip?

YES   NO

6. How many times out fo the last 10, have you bought the
same brand of this product?

_____ times

7. What is your preference for the brand you buy most often?

weak   moderate   strong

8. Overall, how risky do you think it would be to buy an
unfamiliar brand of this product?

low   medium   high

9. Overall, how satisfied are you with the selection of
products at this Commissary?

satisfied   dissatusfied   no opinion

10. Compared to other stores, do you think the Commissary
is out of the items it normally carriers (MORE THE SAME
LESS) than other sotres.

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11. Usually, if an item you wanted was not available when you shopped at the Commissary, would you be more likely to:

(Circle   go to another store
response)   buy it at the Commissary later
                           substitute another item

12. Of all the grocery and household needs purchased by your family unit, approximately what % do YOU PERSONALLY buy?

_____%

13. Approximately what % of your total household grocery purchases are made at the Commissary as opposed ot other stores?

_____% at Commissary

14. Sex: M   F

15. Age: _____

16. What is the highest level of education you have completed?

____less than B.S. diploma   ____college degree
____H.S. graduate, no college ____some graduate school
____some college   ____graduate degree

17a. Description of Household Unit:

____single, no children   ____married, no children
____single, with children   ____married, children
     living at home   living at home
____single, with children   ____married, with children
     not living at home   not living at home

17b. Ages of children at home: ____, ____, ____, ____,
____, ____

18. Rank of Military Persons in Household: ____, ____
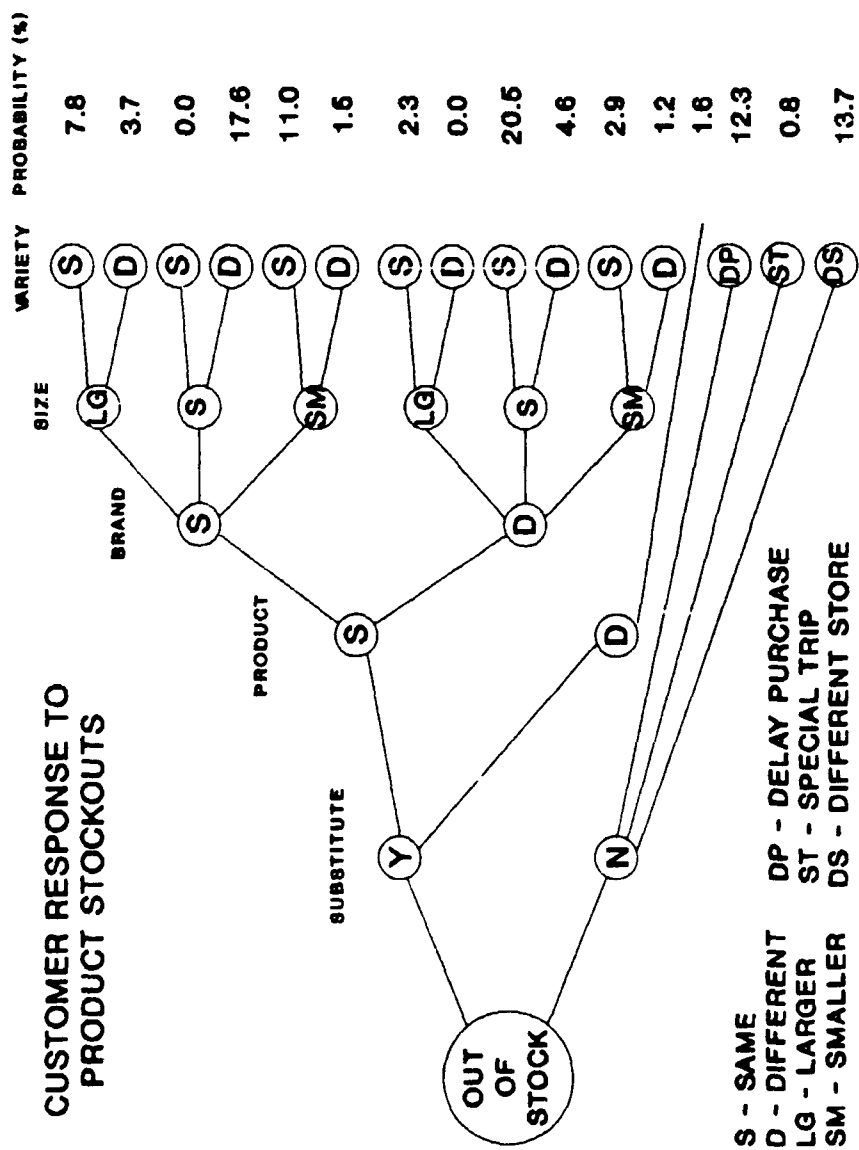
19. Are you a 1 or 2 income household?   1   2

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20. Which of these categories represents your household's total annual income?

____Under $15,000   ____$40,000 to $44,999

____$15,000 to $19,999   ____$45,000 to $49,999

____$20,000 to $24,999   ____$50,000 to $54,999

____$25,000 to $29,999   ____$55,000 to $59,999

____$30,000 to $34,999   ____$60,000 to above

____$35,000 to $39,999

THANK YOU FOR YOUR HELP

CUSTOMER RESPONSE TO PRODUCT STOCKOUTS

S - SAME
D - DIFFERENT   DP - DELAY PURCHASE
LG - LARGER   ST - SPECIAL TRIP
SM - SMALLER   DS - DIFFERENT STORE

VARIETY	PROBABILITY (%)
S	7.8
D	3.7
S	0.0
D	17.6
S	11.0
D	1.5
S	2.3
D	0.0
S	20.5
D	4.6
S	2.9
D	1.2
DP	1.6
ST	12.3
DS	0.8
	13.7

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Vita

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13. ABSTRACT *(Maximum 200 words)*

The purpose of this research was to determine whether existing information about out-of-stock behavior could be used to develop a model of the out-of-stock behavior of commissary patrons. The Wright-Patterson Air Force Base Commissary was losing sales because of stockouts. While more inventory was a logical solution, inventory carrying costs and space limitations restricted the amount of inventory that can be carried. This study developed and analyzed product specific and general out-of-stock models which were developed using the SAS discriminant analysis procedure. It was determined that demographics and shopper characteristics provided the best predictors of the decision to substitute and the brand, size, and variety of the substitute product. Although none of the general out-of-stock models were determined to be useful (a correct rate greater than 80 percent), three product specific models were determined to be useful. Furthermore, the demographic variables were determined to be much more functional than the purchase situation and shopper characteristic variables. Finally, since the size models generally produced results which were far from desired, this research suggests there is no structured method of predicting size given the three variable types.

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